US009274200B2

(12) United States Patent
Chen et al.

(10) Patent No.: US 9,274,200 B2
(45) Date of Patent: Mar. 1, 2016

(54) **FREQUENCY DETECTION CIRCUITS, RADIO FREQUENCY SIGNAL PROCESSING DEVICES AND METHODS FOR CALIBRATING INDUCTANCE AND CAPACITANCE**

(71) Applicant: **VIA Telecom, Inc.**, San Diego, CA (US)

(72) Inventors: **Hsien-Ku Chen**, New Taipei (TW); **Bing-Jye Kuo**, New Taipei (TW); **Fang-Ren Liao**, New Taipei (TW); **Pei-Wei Chen**, New Taipei (TW)

(73) Assignee: **Intel Corporation**, Santa Clara, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/017,391**

(22) Filed: **Sep. 4, 2013**

(65) **Prior Publication Data**

US 2014/0152394 A1 Jun. 5, 2014

(30) **Foreign Application Priority Data**

Dec. 4, 2012 (CN) 2012 1 0512819

(51) **Int. Cl.**

G01R 35/00	(2006.01)
G01R 31/02	(2006.01)
G01R 31/06	(2006.01)
G01R 31/28	(2006.01)

(52) **U.S. Cl.**

CPC ***G01R 35/00*** (2013.01); ***G01R 35/005*** (2013.01); *G01R 31/028* (2013.01); *G01R 31/06* (2013.01); *G01R 31/2822* (2013.01)

(58) **Field of Classification Search**

CPC H03B 5/04; H03G 3/30; G01R 31/028
USPC .... 331/117 R, 167; 330/284; 455/127.2
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,221,924	B2 *	5/2007	Zheng et al.	455/307
2011/0275341	A1 *	11/2011	Landmark et al.	455/318
2013/0281042	A1 *	10/2013	Wang et al.	455/311
2013/0295863	A1 *	11/2013	Shanan	455/226.2
2014/0120853	A1 *	5/2014	Laskar	455/127.2

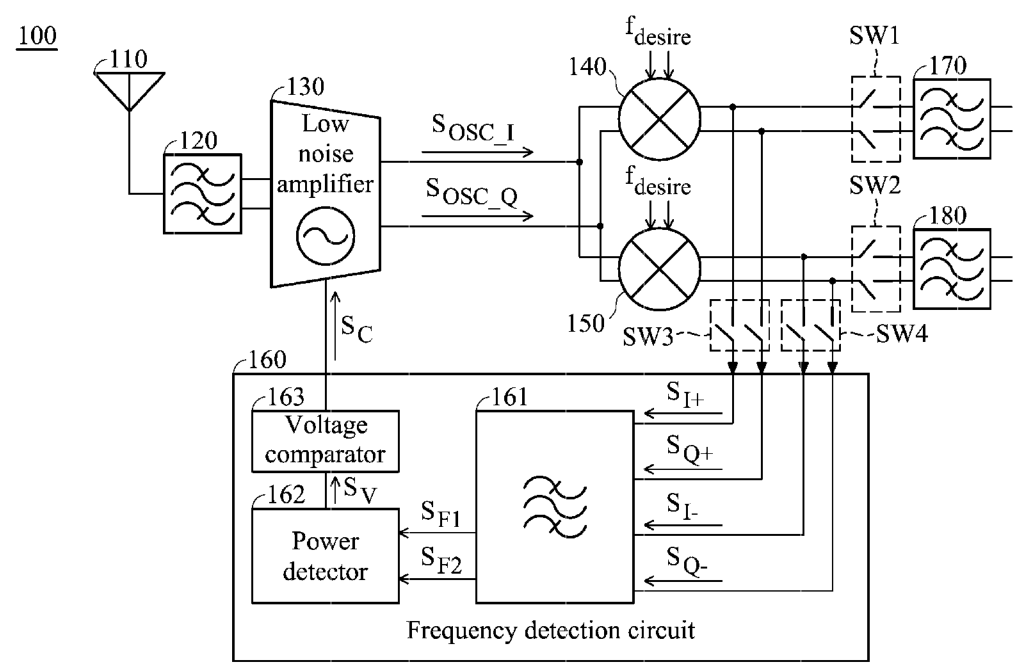
* cited by examiner

Primary Examiner — Jeffrey Shin
(74) *Attorney, Agent, or Firm* — Schiff Hardin LLP

(57) **ABSTRACT**

A frequency detection circuit includes a filter, a power detector and a voltage comparator. The filter receives and filters a converted signal to generate a filtered signal. The power of the filtered signal relates to a frequency of the converted signal. The power detector generates a voltage according to the power of the filtered signal. The voltage comparator compares the voltage with multiple reference voltages to generate multiple comparison results. At least one of the inductance and capacitance of an LC tank in an amplifier is adjusted according to the comparison results.

14 Claims, 7 Drawing Sheets



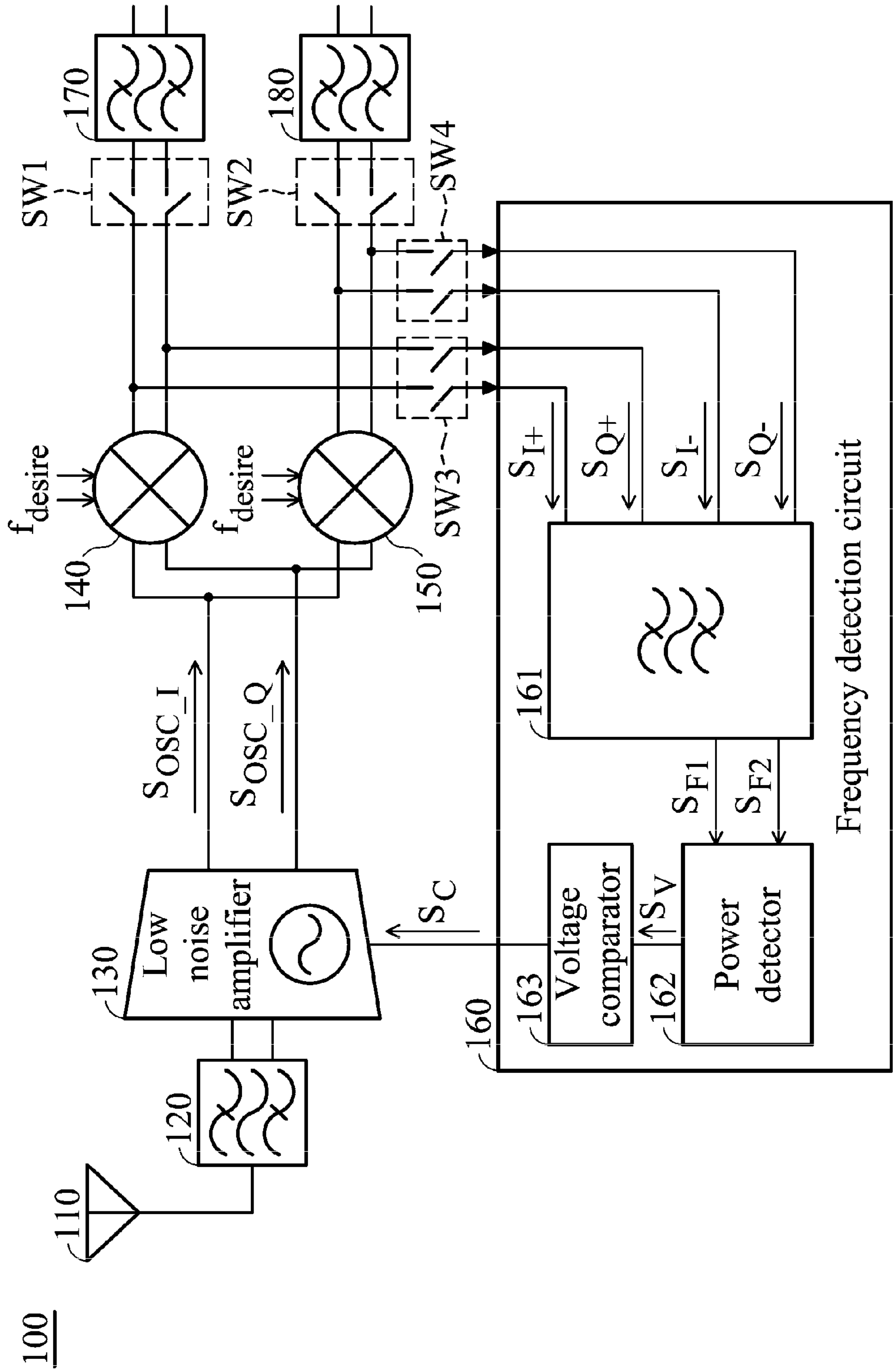

100
110
120
130
Low noise amplifier
140
150
f desire
f desire
S OSC_I
S OSC_Q
S C
SW1
SW2
SW3
SW4
170
180
160
161
162
163
S I+
S Q+
S I-
S Q-
S F1
S F2
S V
Voltage comparator
Power detector
Frequency detection circuit

FIG. 1

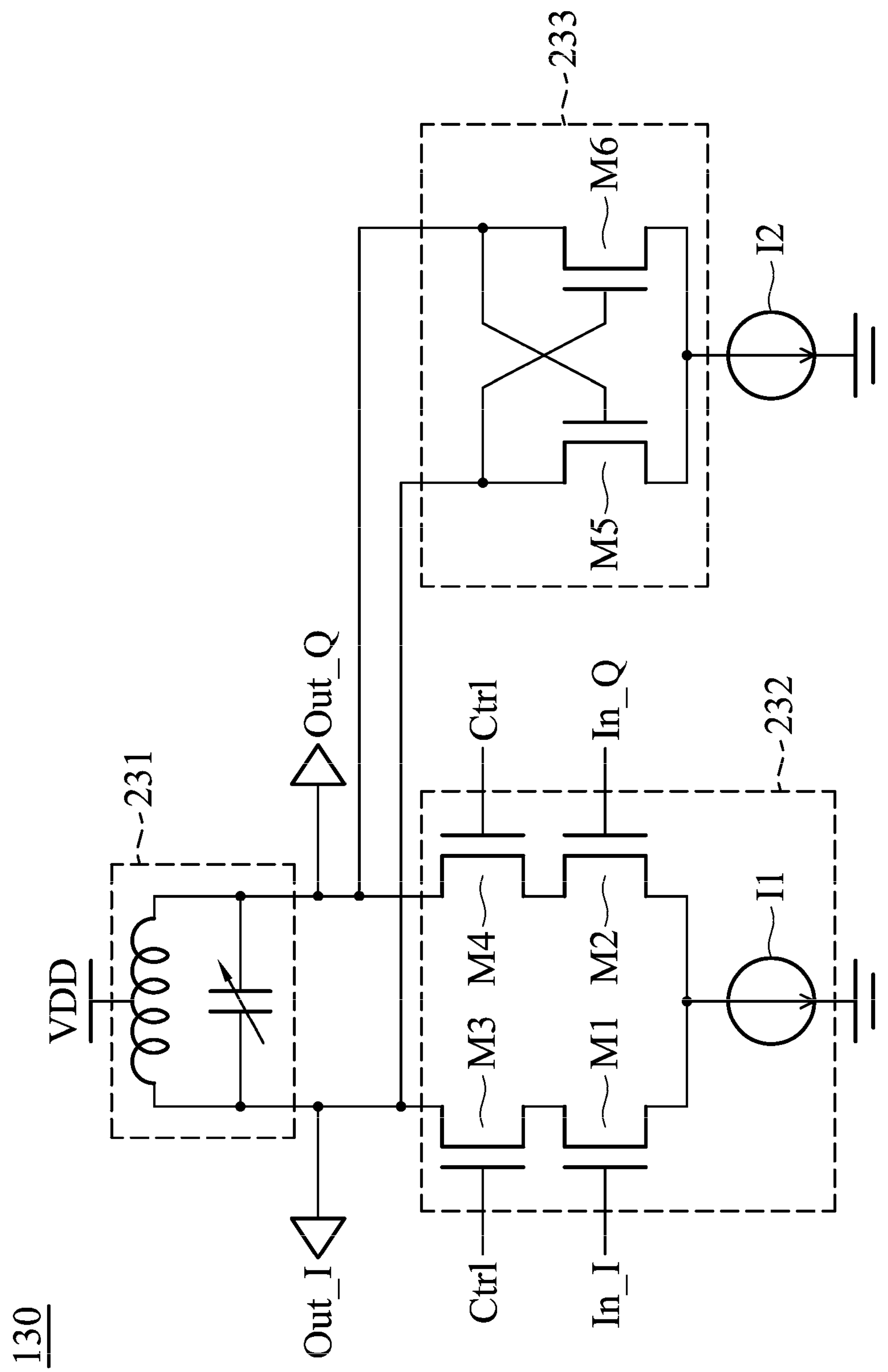

130
VDD
231
Out_I
Out_Q
Ctrl
Ctrl
In_I
In_Q
M1
M2
M3
M4
M5
M6
I1
I2
232
233

FIG. 2

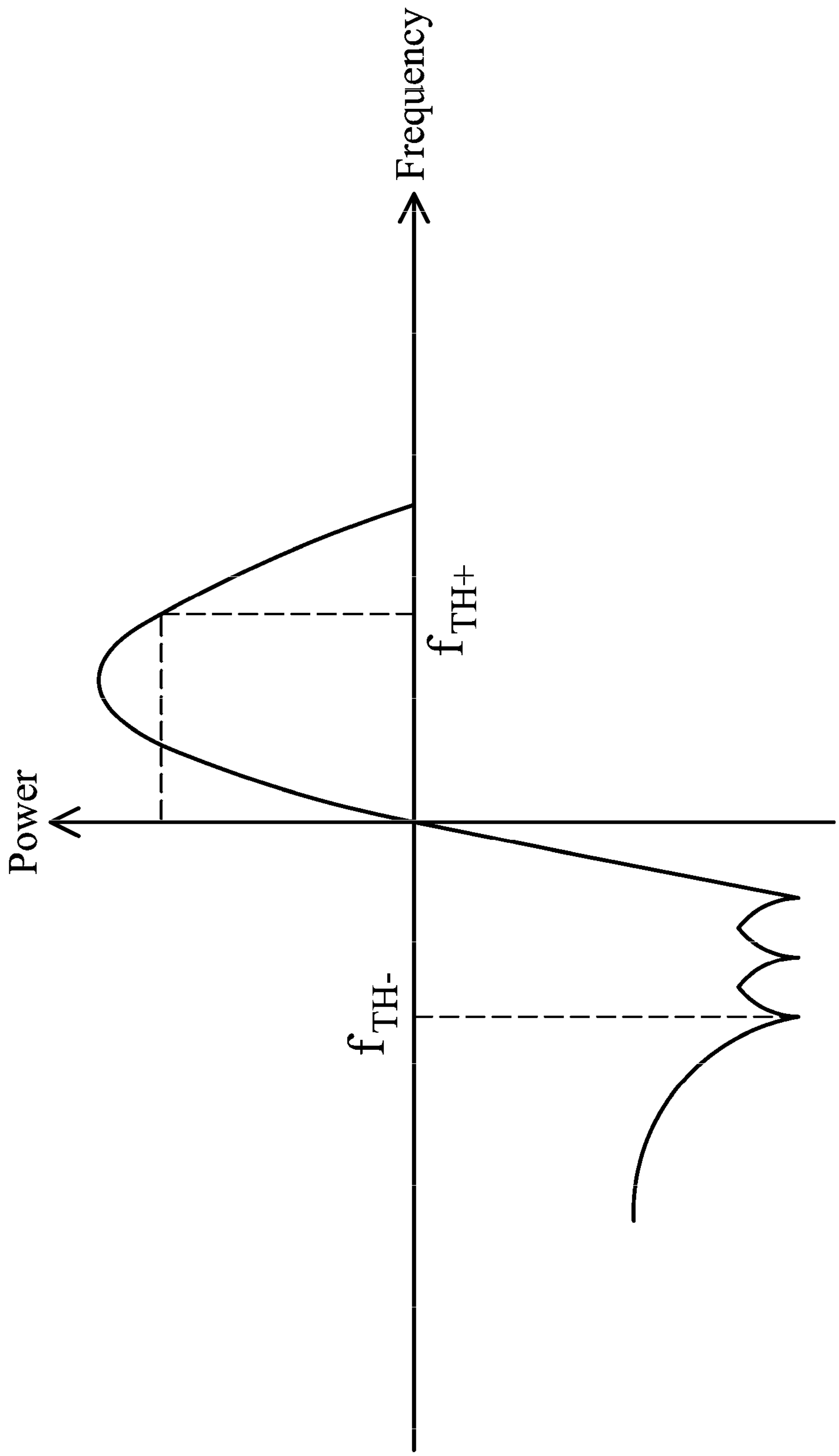


FIG. 3

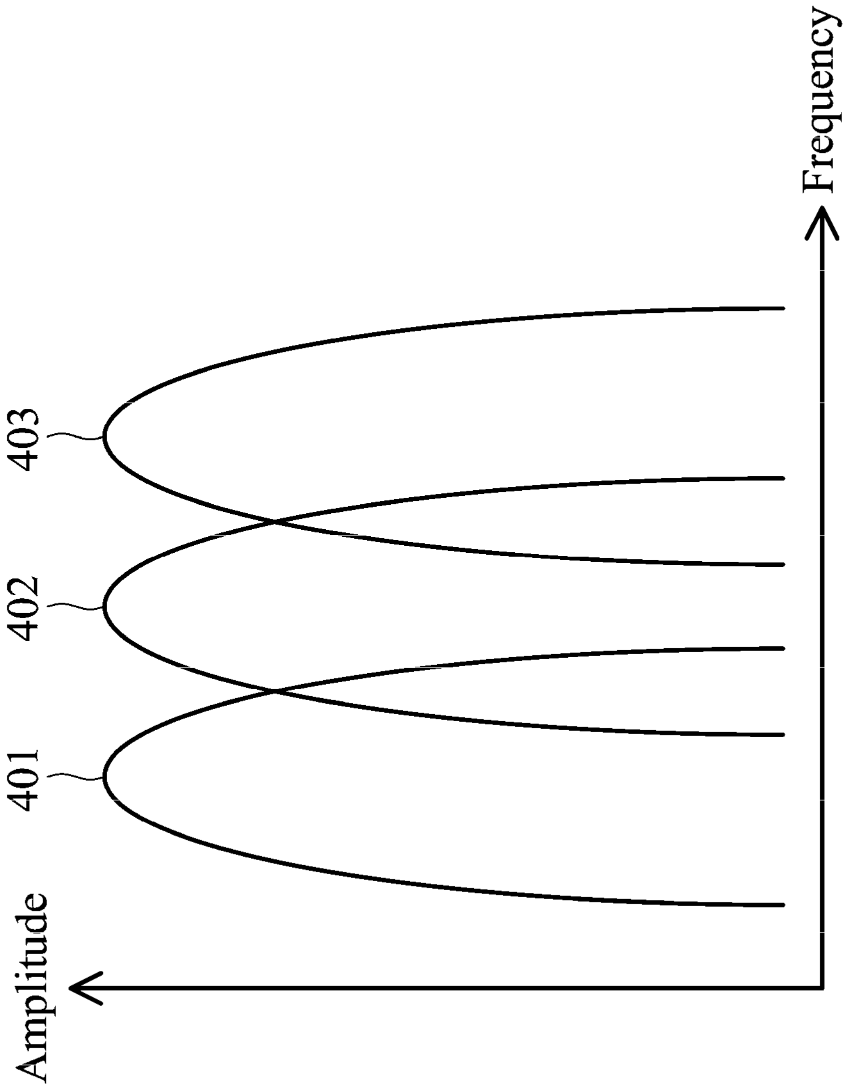


FIG. 4

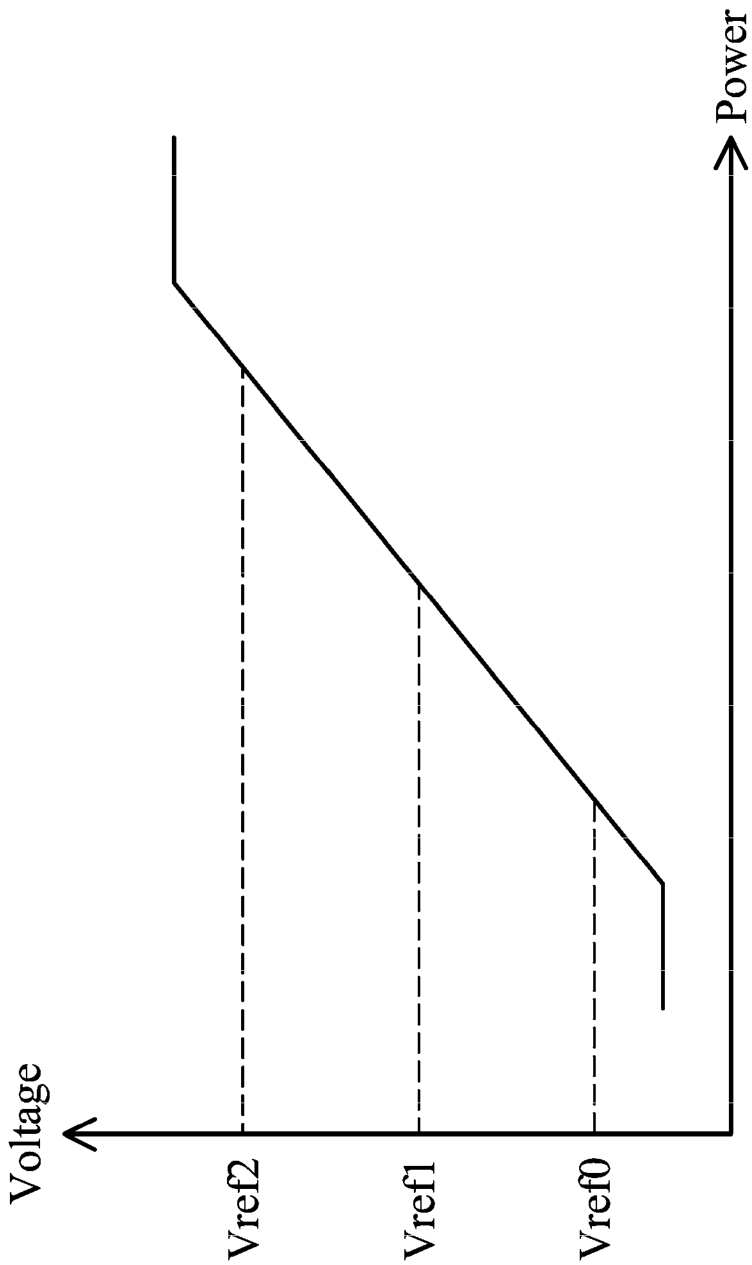


FIG. 5

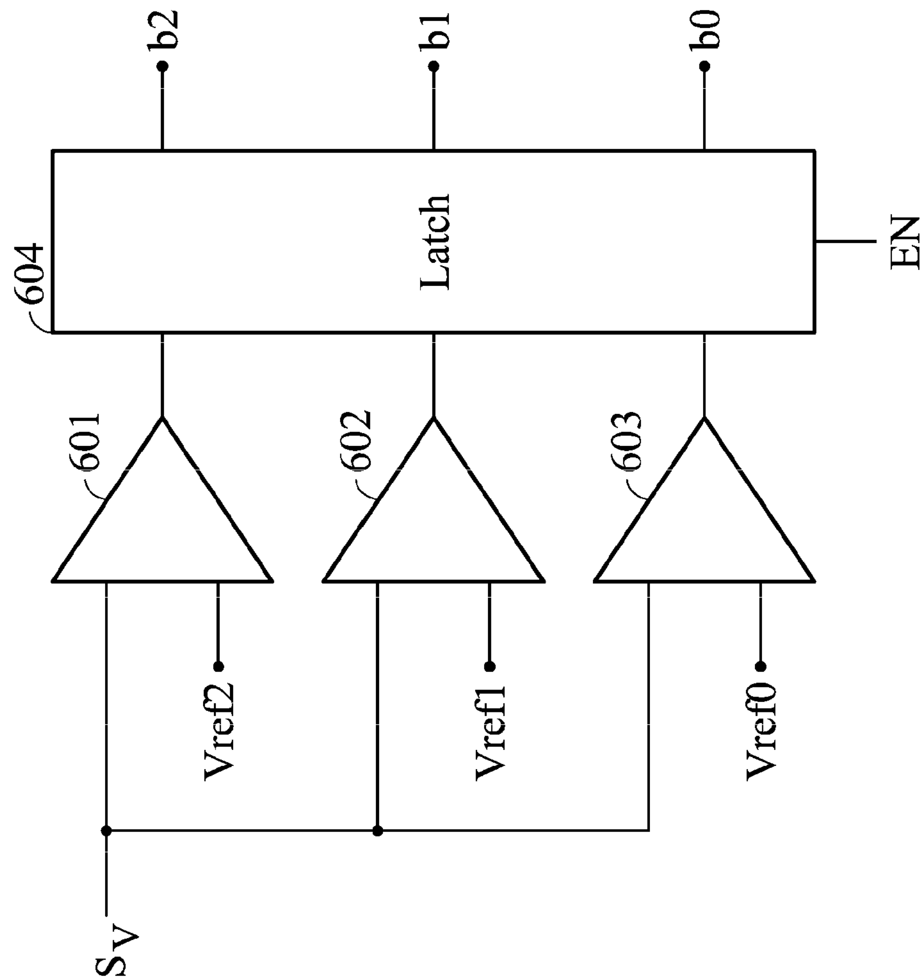


FIG. 6

600

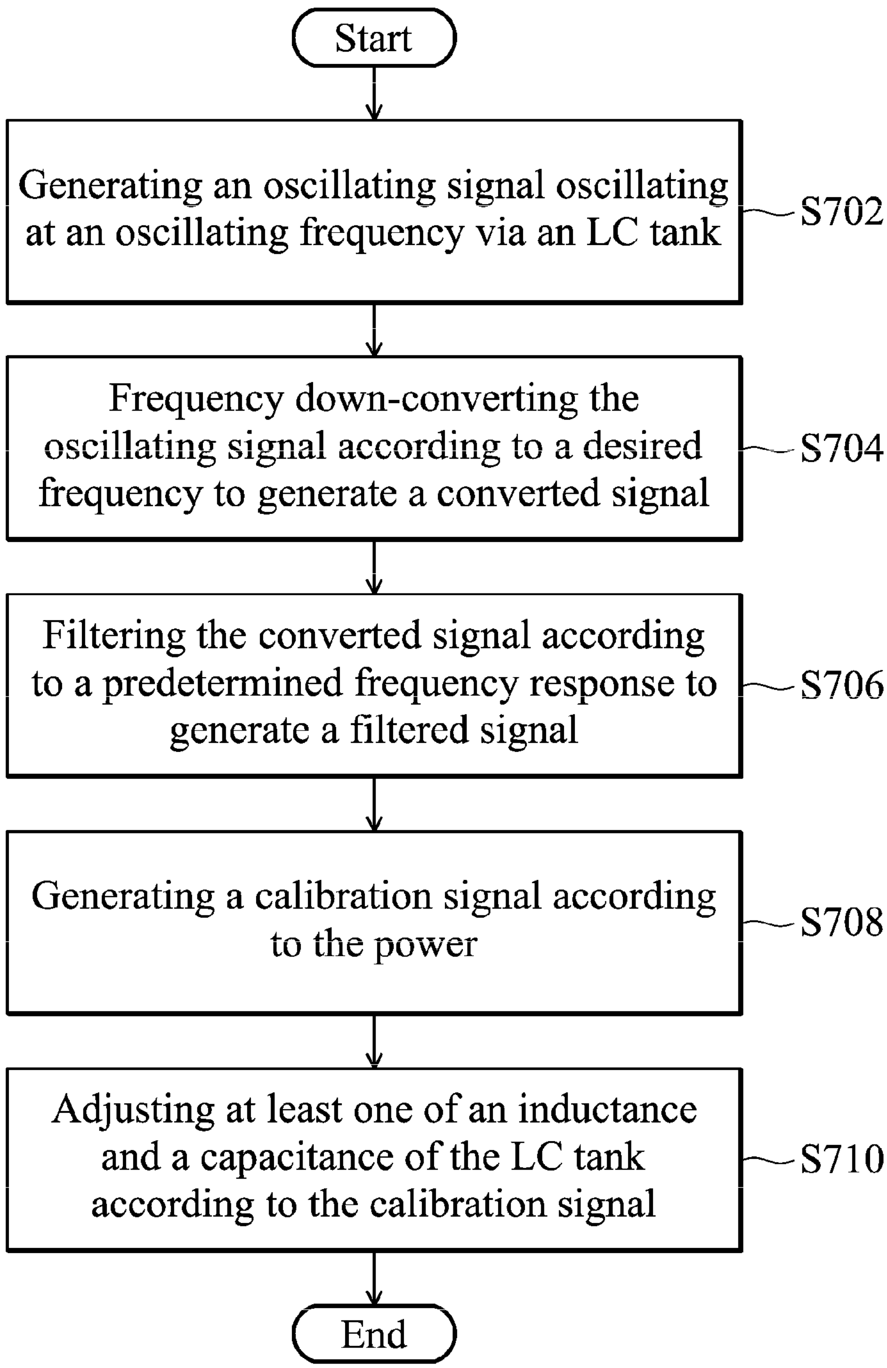

Start
Generating an oscillating signal oscillating at an oscillating frequency via an LC tank
S702
Frequency down-converting the oscillating signal according to a desired frequency to generate a converted signal
S704
Filtering the converted signal according to a predetermined frequency response to generate a filtered signal
S706
Generating a calibration signal according to the power
S708
Adjusting at least one of an inductance and a capacitance of the LC tank according to the calibration signal
S710
End

FIG. 7

FREQUENCY DETECTION CIRCUITS, RADIO FREQUENCY SIGNAL PROCESSING DEVICES AND METHODS FOR CALIBRATING INDUCTANCE AND CAPACITANCE

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority of China Patent Application No. 201210512819.7, filed on Dec. 4, 2012, the entirety of which is incorporated by reference herein.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a method and circuit for calibrating inductance and capacitance, and more particularly, to a method and circuit for calibrating inductance and capacitance by using an image rejection filter to compensate for process variations.

2. Description of the Related Art

Passive components that are used in Radio Frequency (RF) Integrated Circuits (ICs) typically have relatively large process variations. This leads to a direct trade-off between the accuracy of the resonant or resonance frequency and the bandwidth of the circuit.

As a result it is common practice to use relatively low-quality (or called low-Q) resonators in the RF signal path in order to ensure a sufficiently wide bandwidth and, thus, sufficient performance without requiring calibration.

However, the method as described above is not suitable for low bandwidth applications. For example, in the fields of global positioning system (GPS) or Bluetooth communications, because the system operation bandwidth is small, a low bandwidth amplifier is used. Therefore, in low bandwidth applications, high-quality designs are adopted to suppress the out-band spur while achieving low power consumption at the same time.

Accordingly, in low bandwidth systems, a novel method and circuit for calibrating inductance and capacitance to accurately detect the frequency drift caused by process variations and effectively calibrate the inductance and capacitances so as to compensate for the frequency drift caused by process variations are highly required.

BRIEF SUMMARY OF THE INVENTION

Frequency detection circuits, radio frequency signal processing devices and methods for calibrating inductance and capacitance are provided. An exemplary embodiment of a frequency detection circuit comprises a filter, a power detector and a voltage comparator. The filter receives and filters a converted signal to generate a filtered signal. A power of the filtered signal relates to a frequency of the converted signal. The power detector is coupled to the filter for generating a voltage according to the power of the filtered signal. The voltage comparator compares the voltage with a plurality of reference voltages to generate a plurality of comparison results. At least one of an inductance and a capacitance of an LC tank in an amplifier is adjusted according to the comparison results.

An exemplary embodiment of a radio frequency signal processing device comprises a low-noise amplifier, a mixer and a frequency detection circuit. The low-noise amplifier comprises an LC tank, an amplifier circuit, a cross-coupled transistor pair and a current source. The amplifier circuit is coupled to the LC tank at a pair of differential output terminals. The cross-coupled transistor pair is couple to the LC tank at the pair of differential output terminals. The current source is coupled to the cross-coupled transistor pair. The cross-coupled transistor pair, the LC tank and the current source form a self-oscillation circuit for generating an oscillating signal oscillating at an oscillating frequency according to an inductance and a capacitance of the LC tank. The mixer down-converts the oscillating signal according to a desired frequency to generate a converted signal. The frequency detection circuit is coupled to the low-noise amplifier and the mixer for detecting a frequency of the converted signal and generating a calibration signal according to the frequency. At least one of the inductance and the capacitance of the LC tank is adjusted according to the calibration signal.

An exemplary embodiment of a method for calibrating inductance and capacitance comprises: generating an oscillating signal oscillating at an oscillating frequency via an LC tank; frequency down-converting the oscillating signal according to a desired frequency to generate a converted signal; filtering the converted signal according to a predetermined frequency response to generate a filtered signal, wherein a power of the filtered signal relates to a frequency of the converted signal; generating a calibration signal according to the power; and adjusting at least one of an inductance and a capacitance of the LC tank according to the calibration signal.

A detailed description is given in the following embodiments with reference to the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

The invention can be more fully understood by reading the subsequent detailed description and examples with references made to the accompanying drawings, wherein:

FIG. **1** shows a block diagram of an RF signal processing device according to an embodiment of the invention;

FIG. **2** shows a circuit diagram of a low-noise amplifier according to an embodiment of the invention;

FIG. **3** is a diagram showing an exemplary frequency response according to an embodiment of the invention;

FIG. **4** is a schematic diagram showing frequency drift of a low-noise amplifier according to an embodiment of the invention;

FIG. **5** is a schematic diagram showing the power to voltage conversion according to an embodiment of the invention;

FIG. **6** shows a circuit diagram of a voltage comparator according to an embodiment of the invention; and

FIG. **7** shows a flow chart of a method for calibrating inductance and capacitance according to an embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

The following description is of the best-contemplated mode of carrying out the invention. This description is made for the purpose of illustrating the general principles of the invention and should not be taken in a limiting sense. The scope of the invention is best determined by reference to the appended claims.

FIG. **1** shows a block diagram of an RF signal processing device according to an embodiment of the invention. As shown in FIG. **1**, the RF signal processing device **100** may comprise an antenna **110**, a low-noise amplifier **130**, mixers **140** and **150**, a frequency detection circuit **160** and filters **120**, **170** and **180**. According to an embodiment of the invention, the RF signal processing device **100** may operate in a receiving mode and a calibration mode. When operating in the receiving mode, RF signals are received from the air interface via the antenna **110**, filtered by the filter **120** and then passed to the low-noise amplifier **130**. According to a preferred embodiment of the invention, the RF signals are separated into the in-phase (I) components and the quadrature-phase (Q) components after being filtered by the filter **120**, which benefits subsequent signal processing. However, it should be noted that based on different system designs, in the other embodiments of the invention, the RF signals may also not be separated into the in-phase (I) components and the quadrature-phase (Q) components after being filtered by the filter **120**. Therefore, the invention should not be limited to the embodiment as shown in FIG. **1**.

After filtering, the low-noise amplifier **130** amplifies the filtered RF signals and outputs the amplified RF signals to the mixers **140** and **150**. The mixers **140** and **150** frequency down-convert the amplified RF signals according to a desired frequency f_{desire}, so as to generate intermediate frequency signals or baseband signals. According to an embodiment of the invention, the mixers **140** and **150** may receive a signal oscillating at the desired frequency f_{desire} from a frequency synthesizer, and a value of the desired frequency f_{desire} may be different in the receiving mode and the calibration mode. For example, suppose that the RF signal processing device **100** is an RF signal processing device for a GPS, the value of the desired frequency f_{desire} may be set to 1571.328 MHz in the receiving mode and set to 1575.42 MHz in the calibration mode.

According to an embodiment of the invention, when operating in the receiving mode, the switches SW**3** and SW**4** are opened and the switches SW**1** and SW**2** are closed, such that the mixers **140** and **150** are respectively coupled to the filters **170** and **180** in the receiving mode and the intermediate frequency signals or baseband signals are filtered via the filters **170** and **180** before being provided to the next stage circuit (not shown) for subsequent signal processing. On the other hand, when operating in the calibration mode, the switches SW**1** and SW**2** are opened and the switches SW**3** and SW**4** are closed, such that the mixers **140** and **150** are coupled to the frequency detection circuit **160**. The frequency detection circuit **160** generates a calibration signal S_C according to the signals outputted by the mixers **140** and **150** and feeds the calibration signal S_C back to the low-noise amplifier **130** for calibrating the frequency drift caused by process variation. The circuits and methods for calibrating inductance and capacitance are further illustrated in the following paragraphs.

FIG. **2** shows a circuit diagram of a low-noise amplifier according to an embodiment of the invention. The low-noise amplifier **130** may comprise an LC tank **231**, an amplifier circuit **232**, a cross-coupled transistor pair **233** and a current source **12**. The amplifier circuit **232** and the LC tank **231** are coupled at a pair of differential output terminals Out_I and Out_Q. The cross-coupled transistor pair **233** and the LC tank **231** are also coupled at the pair of differential output terminals Out_I and Out_Q. When the RF signal processing device operates in the receiving mode, the current source I**1** in the amplifier circuit **232** is enabled and the pair of transistors M**3** and M**4** are turned on in response to the control signal Ctrl, such that the amplifier circuit **232** is enabled and the amplifier circuit **232** and the LC tank **231** together form a low-noise amplifier circuit. The transistor pair M**1** and M**2** in the low-noise amplifier circuit receives the RF signals at a pair of differential input terminals In_I and In_Q and amplifies the RF signals. Note that in the receiving mode, the current source **12** is disabled such that the current source **12**, so that the cross-coupled transistor pair **233** does not affect operations of the low-noise amplifier circuit.

On the other hand, when the RF signal processing device operates in the calibration mode, the current source **12** is enabled such that the cross-coupled transistor pair **233**, the LC tank **231** and the current source **12** form a self-oscillation circuit to generate a pair of differential oscillating signals (as the oscillating signals S_{OSC_I} and S_{OSC_Q} shown in FIG. **1**) oscillating at a oscillating frequency according to an inductance and a capacitance of the LC tank **231**. Note that in the calibration mode, the current source I**1** in the amplifier circuit **232** is disabled such that the amplifier circuit **232** is disabled and the pair of transistors M**3** and M**4** are turned off in response to the control signal Ctrl for preventing the oscillating signals from feeding into the input terminals In_I and In_Q via the pair of transistors M**1** and M**2** to affect the other stages of circuits.

According to a preferred embodiment of the invention, the RF signal processing device may first operate in the calibration mode for calibrating the frequency drift caused by process variation in the passive devices (for example, the inductors and the capacitors in the LC tank **231**) in the RF signal processing device. After calibration, the RF signal processing device operates in the receiving mode for receiving and processing the RF signals according to the calibrated inductance and/or capacitance. In this manner, the performance degradation of the RF signal processing due to the frequency drift can be reduced.

Referring back to FIG. **1**, as discussed above, in the calibration mode, the low-noise amplifier **130** may first generate the oscillating signals S_{OSC_I} and S_{OSC_Q} through the LC tank **231**. The mixers **140** and **150** frequency down-convert the oscillating signals S_{OSC_I} and S_{OSC_Q} according to the desired frequency f_{desire} to generate a plurality of converted signals. In the embodiment, the converted signals may comprise the 0-degree signal S_{I+}, 90-degree signal S_{Q+}, 180-degree signal S_{I-} and 270-degree signal S_{Q-}.

The frequency detection circuit **160** may be coupled to the mixers **140** and **150** and the low-noise amplifier **130** for detecting a frequency of the converted signals and generate the calibration signal S_C according to the frequency. According to an embodiment, the frequency detection circuit **160** may comprise a filter **161**, a power detector **162** and a voltage comparator **163**. The filter **161** may receive and filter converted signals to generate filtered signals S_{F1} and S_{F2}. According to an embodiment of the invention, the filter **161** may be selected as an image rejection filter (IMRF) for filtering the converted signals according to a predetermined frequency response such that a power of the filtered signals S_{F1} and S_{F2} relates to a frequency of the converted signals.

FIG. **3** is a diagram showing an exemplary frequency response according to an embodiment of the invention. As shown in FIG. **3**, when the frequency of the input signal does not exceed a predetermined range (for example, between the frequency thresholds f_{TH+} and f_{TH-}), the power of the output signal is proportional to the frequency of the input signal. Since the input signals are the signals generated by frequency down-converting the oscillating signals S_{OSC_I} and S_{OSC_Q} via the mixers **140** and **150**, when the desired frequency f_{desire} is designed as the transmission frequency required by the communication system (for example, the 1575.42 MHz for GPS system as discussed above), the power of the signals outputted by the filter **161** reflects the frequency drift due to process variation.

For example, when the oscillating frequency f_{OSC} of the oscillating signal generated by the LC tank **231** is about the desired frequency f_{desire}, it means that the frequency drift caused by the process variation is about 0 Hz. Therefore, the frequency of the signals after being frequency down-converted by the mixers **140** and **150** is about 0 Hz. Similarly, when the oscillating frequency f_{OSC} of the oscillating signal generated by the LC tank **231** is greater than the desired frequency f_{desire}, it means that the frequency drift caused by the process variation is greater than 0 Hz. Therefore, the frequency of the signals after being frequency down-converted by the mixers **140** and **150** is positive. When the oscillating frequency f_{OSC} of the oscillating signal generated by the LC tank **231** is smaller than the desired frequency f_{desire}, it means that the frequency drift caused by the process variation is smaller than 0 Hz. Therefore, the frequency of the signals after being frequency down-converted by the mixers **140** and **150** is negative.

As shown in FIG. **3**, when the frequency of the input signal is between the frequency thresholds f_{TH+} and f_{TH-}, the power of the output signal increases as the frequency of the input signal increases. Therefore, the power of the output signal reflects the amount of frequency drift caused by the process variation. Note that the frequency response as shown in FIG. **3** is just one of a plurality of embodiments of the invention. Those who are skilled in this technology can still design different frequency responses according to different system requirements based on the concept of this invention, such that different relationships may be generated between the frequency of the input signal and the power of the output signal and/or the frequency thresholds may also have different values. Therefore, the invention should not be limited to the embodiment as shown in FIG. **3**.

FIG. **4** is a schematic diagram showing frequency drift of a low-noise amplifier according to an embodiment of the invention. As shown in FIG. **4**, the curves **401**~**403** shows the possible frequency responses of the low-noise amplifier, where the curve **402** is an ideal frequency response when there is no process variation (that is, the typical-typical (TT) process corner), the curve **401** is a frequency response in the slow-slow (SS) process corner, and the curve **403** is a frequency response in the fast-fast (FF) process corner. As shown in FIG. **4**, in the FF process corner, the operation band of the low-noise amplifier is in the high frequency area and in the SS process corner, the operation band of the low-noise amplifier is in the low frequency area.

Therefore, according to a concept of the invention, in the calibration mode, the oscillating signals are generated via the self-oscillation circuit in the low-noise amplifier. The oscillating signals are next frequency down-converted via the mixers **140** and **150** and the converted signals are filtered by the filter **161**. The power of the filtered signals reflects whether the operation band of the low-noise amplifier is close to the high frequency area or the low frequency area due to process variation, and further reflects the amount of frequency drift.

After filtering, the power detector **162** transfers the power of the filtered signals S_{F1} and S_{F2} into the corresponding voltage. FIG. **5** is a schematic diagram showing the power to voltage conversion according to an embodiment of the invention. As shown in FIG. **5**, the power of the input signal may have a corresponding voltage value, and the voltage signal S_V generated by the power detector **162** is transmitted to the voltage comparator **163** to be compared with a plurality of reference voltages (such as the reference voltages Vref**0**, Vref**1** and Vref**2**).

FIG. **6** shows a circuit diagram of a voltage comparator according to an embodiment of the invention. According to an embodiment of the invention, the voltage comparator **600** may comprise a plurality of comparators, such as the comparators **601**, **602** and **603**, for respectively comparing the voltage of the voltage signal S_V with one of the reference signals Vref**0**, Vref**1** and Vref**2**, to generate a plurality of comparison results.

According to an embodiment of the invention, the comparison results may be represented by bits, such as the bits b**0**, b**1** and b**2** as shown. The voltage comparator **600** may comprise a latch **604** for receiving and latching the comparison results and outputting the comparison results as the calibration signal S_C at adequate times in response to the enable signal EN. The calibration signal S_C is fed back to the low-noise amplifier **130** so as to adjust at least one of the inductance and the capacitance of the LC tank **231**.

According to an embodiment of the invention, the LC tank **231** may comprise a plurality of capacitors that are selectively coupled in parallel for adjusting the capacitance according to the calibration signal S_C. Table 1 shows an example of capacitance adjustment according to an embodiment of the invention.

TABLE 1

capacitance adjustment example

b2	b1	b0	C1 C0
1	1	1	1 1
0	1	1	0 1
0	0	1	0 0
0	0	0	0 0

As shown in Table 1, in the example, the LC tank **231** may comprise three capacitors coupled in parallel and the calibration signal S_C may carry two-bits of data. The bits C**1** and C**0** are the results obtained by performing logic operations on the bits b**0**, b**1** and b**2** (for example, the logic operations may be performed inside of the latch **604**). For example, when the voltage signal S_V is smaller than the reference signals Vref**0**, Vref**1** and Vref**2**, the obtained comparison results may all be 0, and the resulting bits C**1** and C**0** may all be 0. Therefore, two capacitors in the LC tank **231** may be controlled to be de-coupled from the inductor such that the overall capacitance is adjusted. For another example, when the voltage signal S_V is greater than the reference signals Vref**0**, Vref**1** and Vref**2**, the obtained comparison results may all be 1, and the resulting bits C**1** and C**0** may all be 1. Therefore, all the capacitors in the LC tank **231** may be controlled to be coupled to the inductor such that the overall capacitance is adjusted.

Note that the capacitance adjusting method as illustrated above is just one of a plurality of embodiments of the invention. Those who are skilled in this technology can still adjust the capacitance and/or inductance of the LC tank **231** in different ways based on the concept illustrated above, and the invention should not be limited thereto.

FIG. **7** shows a flow chart of a method for calibrating inductance and capacitance according to an embodiment of the invention. First of all, an oscillating signal oscillating at an oscillating frequency is generated via an LC tank (Step S**702**). Next, the oscillating signal is frequency down-converted according to a desired frequency to generate a converted signal (Step S**704**). Next, the converted signal is filtered according to a predetermined frequency response to generate a filtered signal (Step S**706**), such that a power of the filtered signal relates to a frequency of the converted signal. Next, a calibration signal is generated according to the power (Step S**708**). Finally, at least one of an inductance and a capacitance of the LC tank is adjusted according to the calibration signal (Step S**710**).

The proposed methods for calibrating inductance and capacitance can effectively compensate for the frequency drift caused by process variation via inductance and/or capacitance calibration, such that the performance of RF signal processing will not degrade due to frequency drift. In addition, the proposed circuits and methods for calibrating inductance and capacitance have the advantages of having a small circuit area and low power consumption as compared with the conventional designs.

While the invention has been described by way of example and in terms of preferred embodiment, it is to be understood that the invention is not limited thereto. Those who are skilled in this technology can still make various alterations and modifications without departing from the scope and spirit of this invention. Therefore, the scope of the present invention shall be defined and protected by the following claims and their equivalents.

What is claimed is:

1. A frequency detection circuit, comprising:

a filter, receiving a converted signal and filtering the converted signal according to a predetermined frequency response to generate a filtered signal, wherein a power of the filtered signal relates to a frequency of the converted signal;

a power detector, coupled to the filter for generating a voltage according to the power of the filtered signal; and

a voltage comparator, comparing the voltage with a plurality of reference voltages to generate a plurality of comparison results,

wherein at least one of an inductance and a capacitance of an LC tank in an amplifier is adjusted according to the comparison results in a calibration mode, wherein the amplifier operates in at least the calibration mode and a receiving mode, and in the calibration mode, an amplifier circuit of the amplifier is disabled and a current source of the amplifier is enabled such that a cross-coupled transistor pair of the amplifier, the LC tank and the current source form a self-oscillation circuit for generating an oscillating signal.

2. The frequency detection circuit as claimed in claim **1**, wherein the filter is an image rejection filter.

3. The frequency detection circuit as claimed in claim **1**, wherein the converted signal is generated by frequency down-converting the oscillating signal oscillating at an oscillating frequency according to a desired frequency, and the LC tank is utilized to generate the oscillating signal.

4. The frequency detection circuit as claimed in claim **1**, wherein the voltage comparator comprises a plurality of comparators for comparing the voltage with one of the reference voltages to generate the comparison results.

5. A radio frequency signal processing device, comprising:

a low-noise amplifier, comprising:

an LC tank;

an amplifier circuit, coupled to the LC tank at a pair of differential output terminals;

a cross-coupled transistor pair, couple to the LC tank at the pair of differential output terminals; and

a current source, coupled to the cross-coupled transistor pair,

wherein the cross-coupled transistor pair, the LC tank and the current source form a self-oscillation circuit for generating an oscillating signal oscillating at an oscillating frequency according to an inductance and a capacitance of the LC tank;

a mixer, down-converting the oscillating signal according to a desired frequency to generate a converted signal; and

a frequency detection circuit, coupled to the low-noise amplifier and the mixer for detecting a frequency of the converted signal and generating a calibration signal according to the frequency,

wherein at least one of the inductance and the capacitance of the LC tank is adjusted according to the calibration signal, and

wherein the low-noise amplifier operates in at least a calibration mode and a receiving mode, and in the calibration mode, the amplifier circuit is disabled and the current source is enabled such that the cross-coupled transistor pair, the LC tank and the current source form the self-oscillation circuit for generating the oscillating signal.

6. The radio frequency signal processing device as claimed in claim **5**, wherein the frequency detection circuit further comprises:

a power detector, coupled to the filter for generating a voltage according to the power of the filtered signal; and

a voltage comparator, comparing the voltage with a plurality of reference voltages to generate the calibration signal.

7. The radio frequency signal processing device as claimed in claim **5**, wherein the filter is an image rejection filter.

8. The radio frequency signal processing device as claimed in claim **6**, wherein the voltage comparator comprises a plurality of comparators for respectively comparing the voltage with one of the reference voltages to generate a plurality of comparison results and generate the calibration signal according to the comparison results.

9. The radio frequency signal processing device as claimed in claim **5**, wherein in the receiving mode, the current source is disabled and the amplifier circuit is enabled such that the amplifier circuit and the LC tank form a low-noise amplifier circuit for amplifying a received radio frequency signal.

10. A method for calibrating inductance and capacitance, comprising:

generating an oscillating signal oscillating at an oscillating frequency via an LC tank of a low noise amplifier, wherein the low-noise amplifier operates in at least a calibration mode and a receiving mode, and in the calibration mode, an amplifier circuit of the low noise amplifier is disabled and a current source of the low noise amplifier is enabled such that a cross-coupled transistor pair of the low noise amplifier, the LC tank and the current source form a self-oscillation circuit for generating the oscillating signal;

frequency down-converting the oscillating signal according to a desired frequency to generate a converted signal;

filtering the converted signal according to a predetermined frequency response to generate a filtered signal, wherein a power of the filtered signal relates to a frequency of the converted signal;

generating a calibration signal according to the power; and

adjusting at least one of an inductance and a capacitance of the LC tank according to the calibration signal.

11. The method as claimed in claim **10**, wherein the LC tank is comprised in a low-noise amplifier.

12. The method as claimed in claim **11**, wherein the step of generating the oscillating signal oscillating at the oscillating frequency via the LC tank is performed by a self-oscillation circuit comprised in the low-noise amplifier.

13. The method as claimed in claim **10**, wherein the step of filtering the converted signal according to the predetermined frequency response is performed by an image rejection filter.

14. The method as claimed in claim **10**, wherein the step of generating the calibration signal according to the power further comprises:

generating a voltage according to the power;

comparing the voltage with a plurality of reference voltages to generate a plurality of comparison results; and

generating the calibration signal according to the comparison results.

* * * * *